of tubes **141**. A U-shaped metal strip **148** extending between the sheets **134** and **147** defines a space around the inlet pipe **143**.

The tubes which are aligned with the barriers **148** terminate short of it. The fuel which is circulated through the cooled jet nozzle wall discharges from manifold **138** through a pipe or pipes **149** to the valve **29** which controls its admission to the combustion apparatus.

Plug type combustion chamber

FIGURE 14 illustrates an alternative form of combustion chamber with variable outlet which may be used instead of the corresponding structure shown in FIGURE 1. FIGURE 14 illustrates the rear portion of a combustion chamber **170** which terminates in a converging nozzle **171**. Air and fuel may be supplied to the combustion chamber by any suitable means such as those illustrated in connection with FIGURE 1. A plurality of struts, including struts **173** and **174**, extend inwardly from the wall of the combustion chamber to define a supporting spider for a double-walled nozzle plug support **175**. Cooling fluid, such as gaseous fuel, is supplied through line **32** and strut **173** to the passage **177** between the walls of the support **175**.

The plug **179** which acts to vary the combustion chamber outlet includes a hollow stem **181**, the forward end of which is slidable upon the support **175**, a sliding seal **182** being provided between the two. The support **175** includes a rear portion **183** of reduced diameter on which is slidable a collar **185** connected to the interior of plug **179** by an open-work spider **186**. A ball screw actuating device **187** is mounted within the portion **183** of the support and supported rotatably in a thrust bearing **189**. The inner member or screw **191** of the ball screw actuator connects to web **190** in the rear end of plug **179**. Rotation of the body or nut **192** of the actuator causes the plug to reciprocate on its support, as previously described. The body is rotated by a shaft **194** connected through bevel gears **196** to a radial shaft **195** extending through strut **174** and rotatable by any suitable power actuating device **197**.

Cooling gas admitted through line **173** and flowing rearwardly through the passage **177** is discharged into the interior of the support and flows rearwardly through openings in the spider **186** into the interior of the plug **179**. The plug is also double-walled and the inner wall has an opening **201** at the rear end of the plug. The cooling gas entering between the double walls of the plug flows from the entrance **201** through the annular passage **202** to the forward end of the plug where it is discharged from the annular open end of the double wall at **203** and is burned in the flame from the combustion chamber. Thus the nozzle plug **179** and its support **175** are cooled by fuel subsequently burned.

As will be apparent, the combustion apparatus of FIGURE 14 and likewise that of the previously described form of the invention may have the area of the outlet varied in accordance with the operating condition of the engine to provide most efficient propulsion under various conditions of speed and altitude. Also, the total fuel flow, the control of fuel flow through the two inlet precoolers, the adjustment of the air inlet doors **27**, and the allocation of fuel between the precombustion chamber and the main combustion chamber are variable to provide a broad spectrum of effective operation of the engine. However, my invention is not concerned primarily with the engine overall but rather with the improved combustion chamber and propulsion jet nozzle arrangement, two forms of which have been described.

The description of the preferred embodiments of the invention for the purpose of explaining the principles thereof is not to be considered as limiting or restricting the invention, since many modifications may be made by the exercise of skill in the art.

I claim:

1. A jet propulsion device comprising, in combination, an air duct for conducting combustion air under pressure, a precombustion device supplied with air through the air duct, a heat exchanger supplied with air from the air duct through the precombustion device, a fuel circuit through the heat exchanger, a main combustion chamber supplied with air for combustion from the air duct through the precombustion device and the heat exchanger, the chamber having an outlet for combustion products, a jet propulsion nozzle aligned with the outlet, the nozzle having a throat larger than the said outlet, the nozzle having an entrance passage disposed around the combustion chamber, means including movable air inlet doors operable to admit ambient boundary layer air to or exclude it from the entrance passage, means operable to move the doors and to hold them in desired positions through a range from closed to open, the main combustion chamber and jet propulsion nozzle including double walls adapted for circulation of a cooling medium through the walls, and means for circulating fuel for combustion through the said heat exchanger fuel circuit and the said double walls to the main combustion chamber and the precombustion device for combustion therein.

2. A device as recited in claim **1** including controllable means for varying the area of the combustion chamber outlet.

3. A device as recited in claim **1** including also a compressor connected to supply the said air duct, a turbine connected to drive the compressor, and means to circulate the fuel from the heat exchanger to the turbine as motive fluid for the turbine.

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